

Evaluation of CROPSYST-SIMPOTATO model for simulation of Nitrogen Mineralization in Potato Rotation Systems

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Introduction

In the irrigated agricultural production region of the Pacific Northwest, potato is rotated with wheat, corn, and to a limited extent with alfalfa. Total nitrogen (N) returned to the soil by incorporation of the respective crop residues account for 40 to 147 kg ha⁻¹. Mineralization of N from these crop residues render N into plant available forms. The rate of mineralization is dependent on the soil, climatic and management conditions. The potato growth simulation model, SIMPOTATO (Hodges et al., 1992), was integrated with the multi-year and multi-crop model CROPSYST (Stockle et al., 1994) to simulate crop growth and N dynamics in potato rotation systems. Improved accuracy of simulation of N dynamics in a potato rotation system provides an important tool in the decision making process to determine the amount of N to be applied to meet the respective crop N requirement while minimizing N losses from the rotation cropping systems.

Objectives

- To compare CROPSYST-SIMPOTATO predictions of N mineralization from different crop residues to field measured data
- To use the above model to estimate contributions of mineralized N from residues, of different crops, in relation to potato N uptake

Methods and materials

Field experiment

The study was conducted on a Quincy fine sand near Paterson, WA. In-situ column incubation technique was used to determine the N mineralized during January through September 2000 from corn, wheat, and potato crop residues to a 0.3 m depth. The incubation columns were installed after potato, corn, and wheat harvest and the respective crop residues incorporated to simulate common cultivation practices and conditions. Soil sample at 0.3m depth was taken adjacent to the incubation column to analyze initial status of soil NO₃-N and NH₄-N in KCL extraction. The crop residue from the above soil sample was separated for dry matter estimation (which includes the tops and root residues) and concentration of N in the crop residue was determined to calculate the total N returned to the soil from crop residue (26.5, 20.2, and 8.4 Mg ha⁻¹ respectively for corn, wheat, and potato residue; with total N content of 398, 378, and 121 kg ha⁻¹, respectively). These inputs were used to simulate N mineralization. The sampling area was irrigated during May through September using a center –pivot irrigation system. The columns were capped to prevent irrigation water from entering the columns. Soil mineral N (NO₃-N and NH₄-N) was measured at the end of each incubation period. The duration of the incubation was four to eight weeks during January to May and two weeks during June through September. The differences in concentrations of NO₃-N and NH₄-N in the soil sample at the end of a incubation period and those of the initial sampling represent the amount of N mineralized from the crop residues as well as from the soil organic matter.

The model

The integrated and updated CROPSYST-SIMPOTATO model was used to simulate, first, mineralization from residues according to the field experiment. Then, the model was used to simulate the growth and production of potatoes for the year of the experiment using input residue parameters that represented different residues of a previous crop.

Results

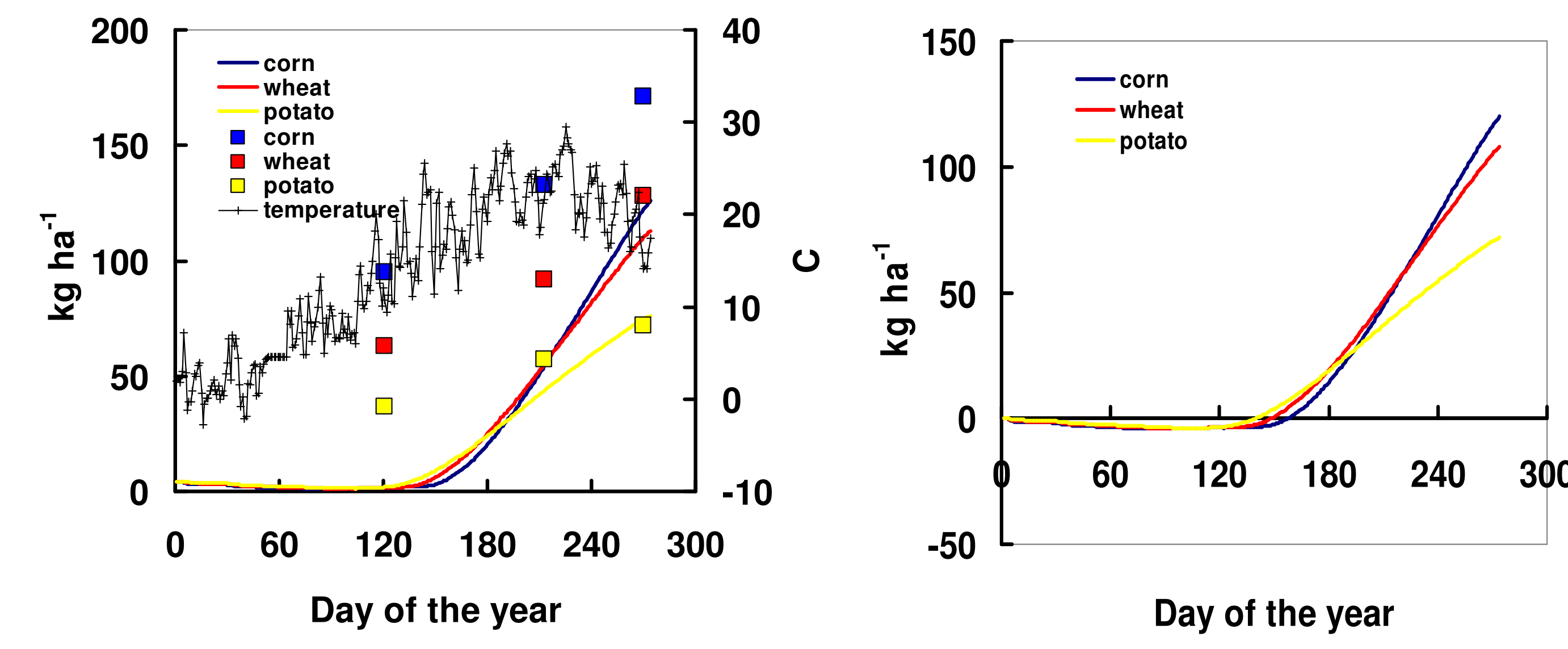


Fig 1. Measured (squares) and simulated (lines) mineralized N (NO₃-N + NH₄-N, kg ha⁻¹) in the top 30 cm of soil from corn, wheat, and potato residues and mean daily air temperature (C).

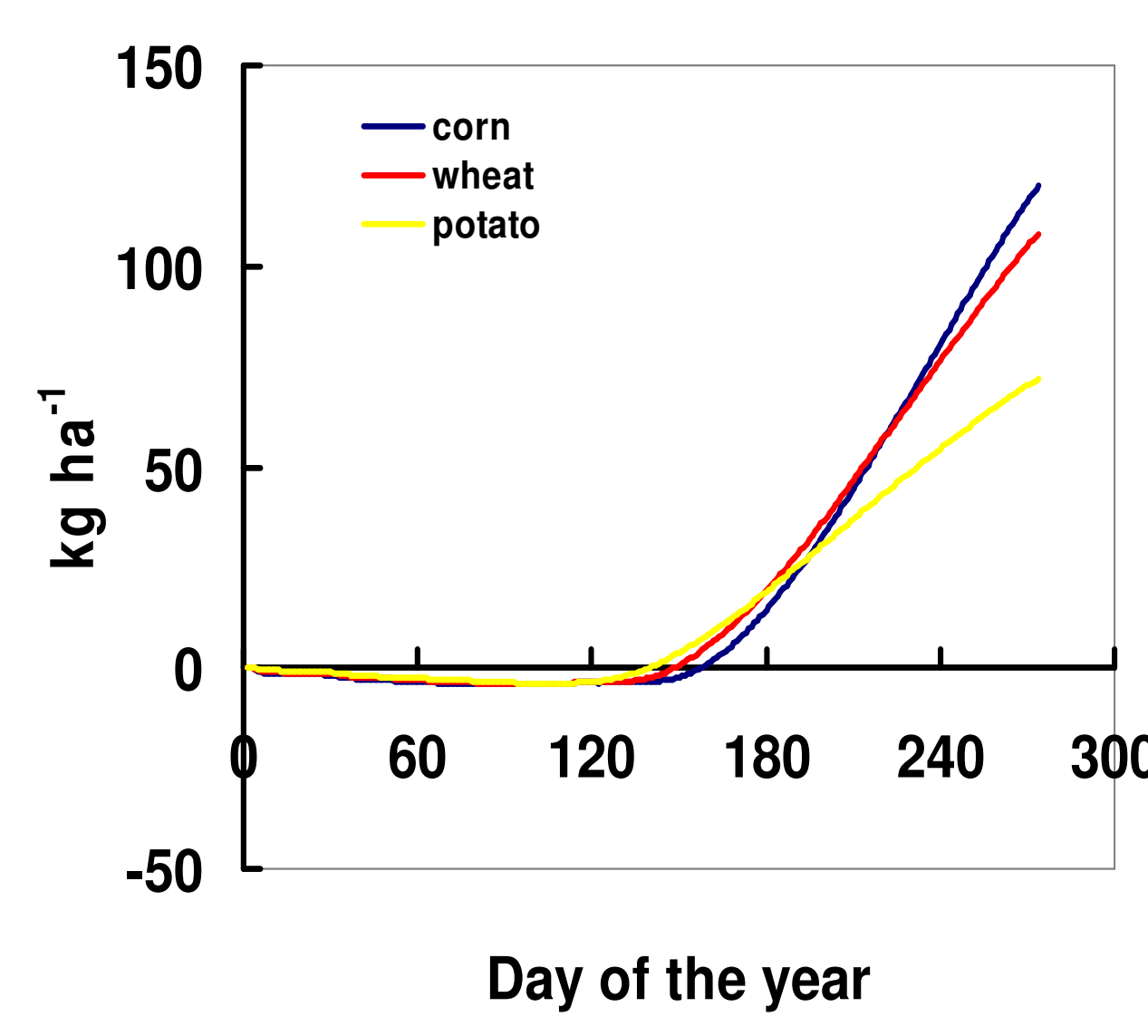


Fig 2. Simulated cumulative net mineralization (kg ha⁻¹ N mineralized – kg ha⁻¹ N immobilized) for corn, wheat, and potato residues.

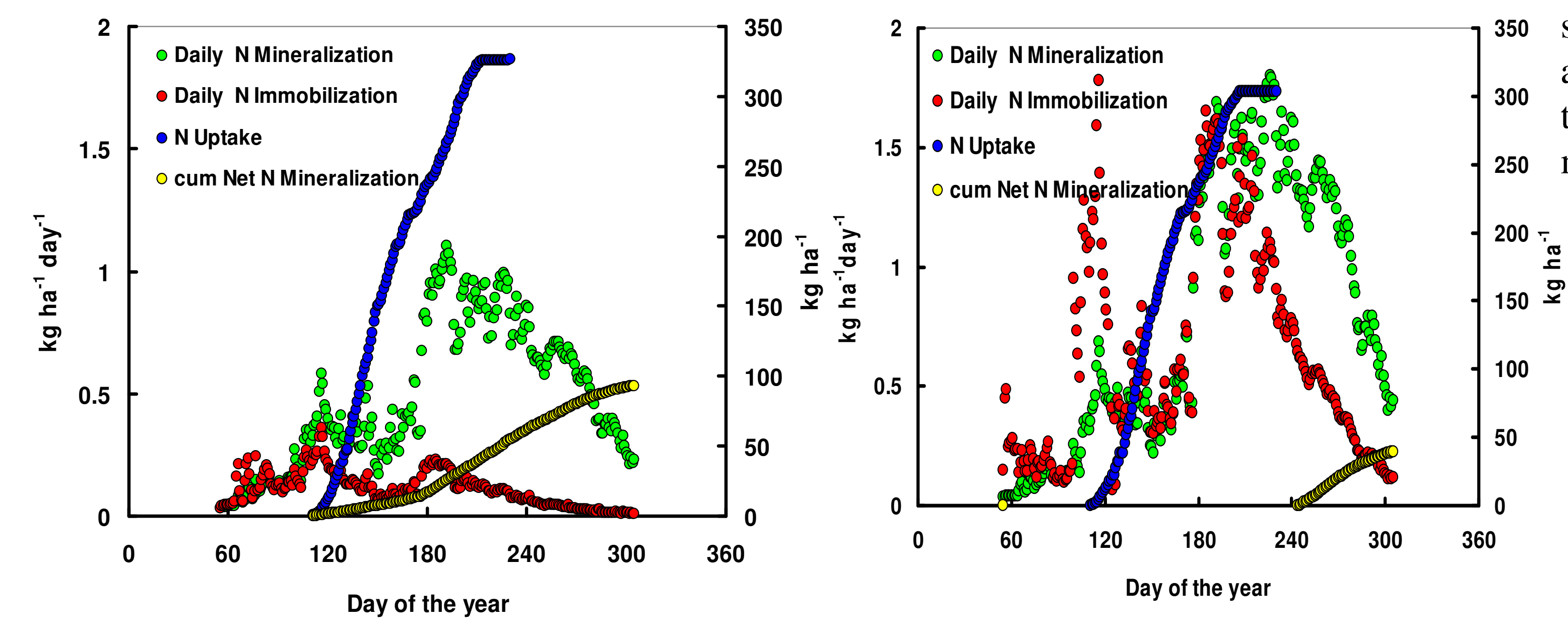


Fig 3. Simulated cumulative potato N uptake, daily N mineralization, daily N immobilization and cumulative net N mineralization during the growth of potato with low residue loading (5 Mg ha⁻¹) and C:N ratio of 30.

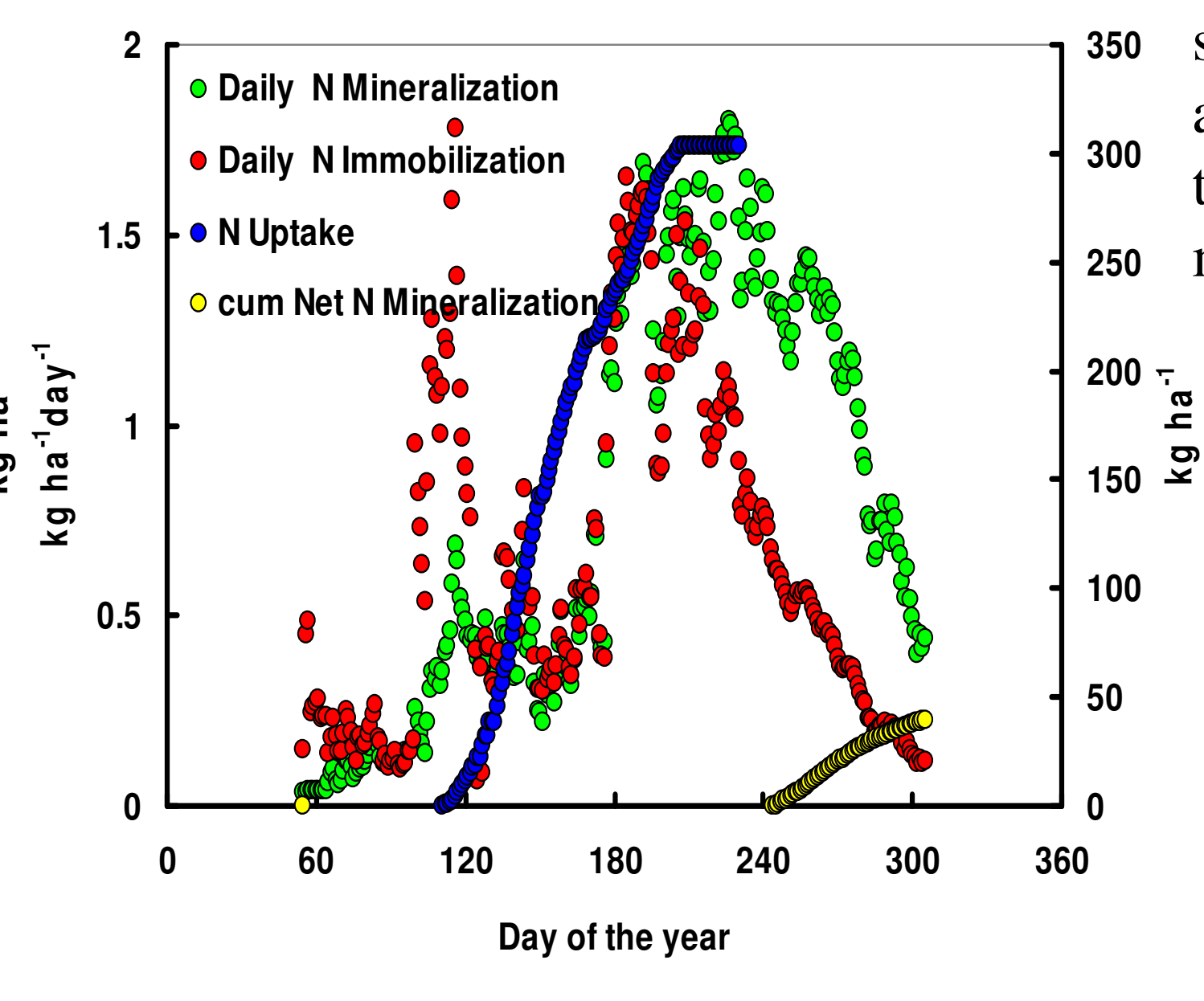


Fig 4. Simulated cumulative potato N uptake, daily N mineralization, daily N immobilization and cumulative net N mineralization during the growth of potato with high residue loading (15 Mg ha⁻¹) and C:N ratio of 50.

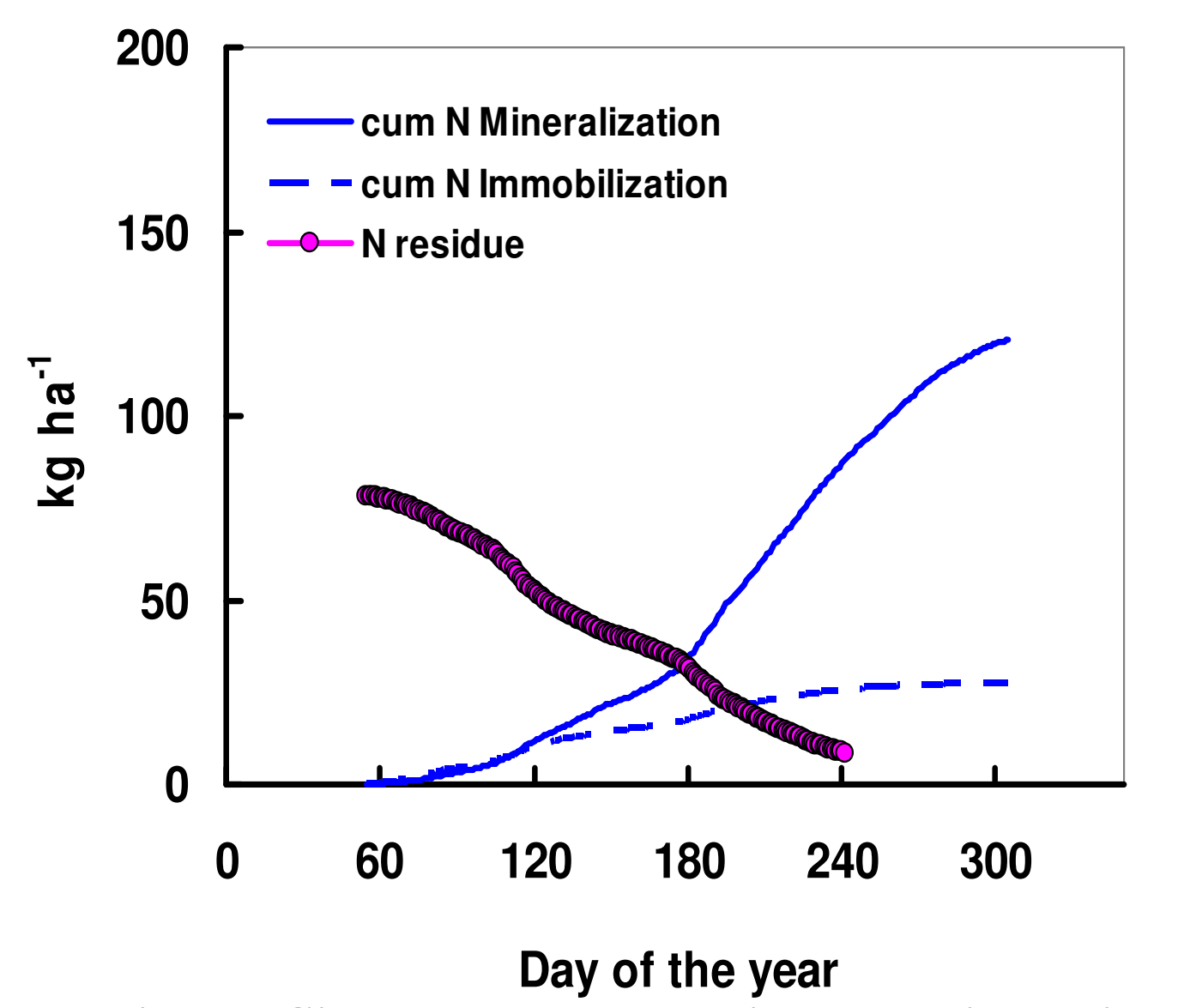


Fig 5. Simulated cumulative N mineralization, cumulative N immobilization and N in the residue during the growth of potato with low residue loading (5 Mg ha⁻¹) and C:N ratio of 30.

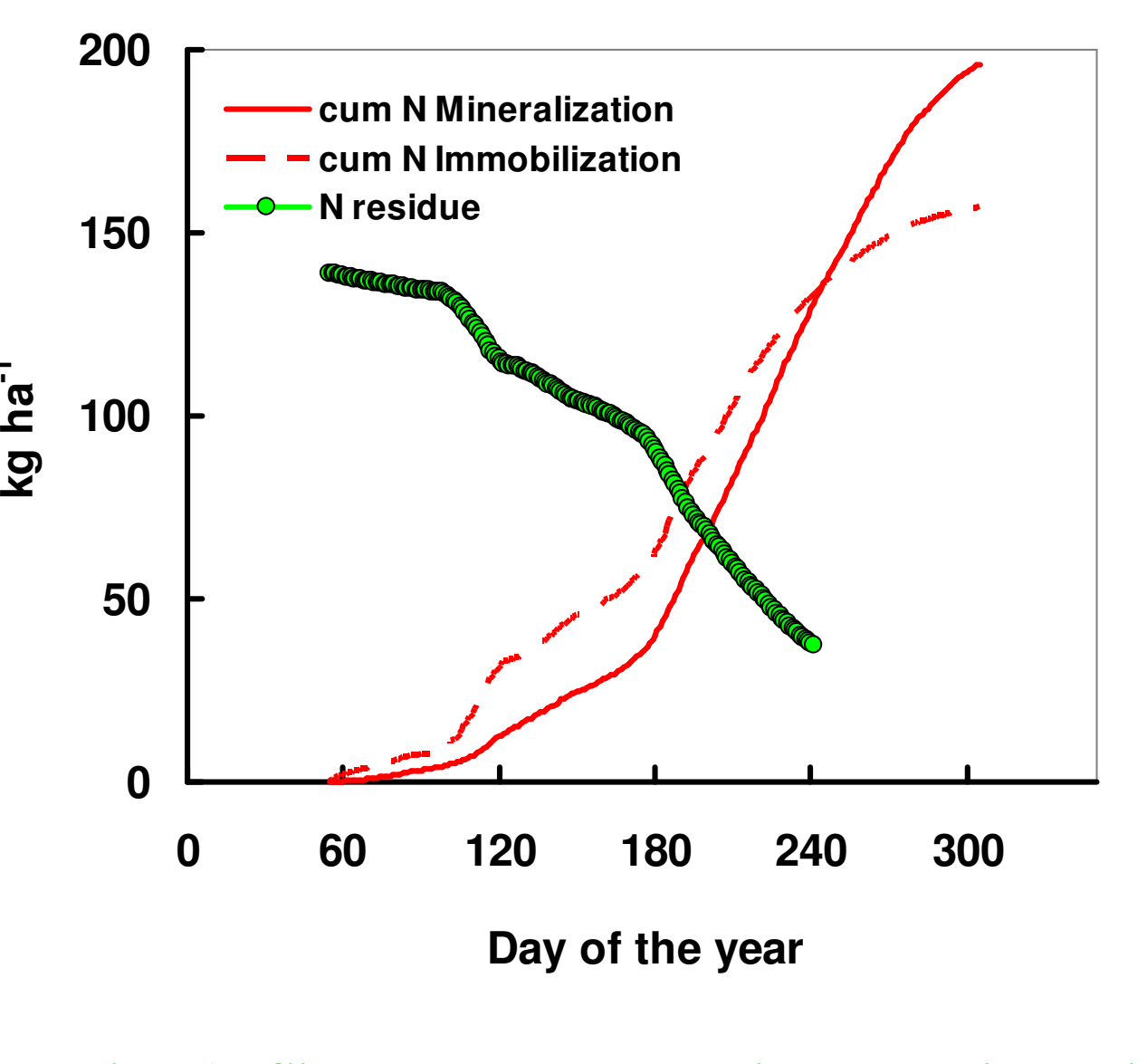


Fig 6. Simulated cumulative N mineralization, cumulative N immobilization and N in the residue during the growth of potato with high residue loading (15 Mg ha⁻¹) and C:N ratio of 50.

The amounts of N mineralized from Potato, and wheat residues under irrigated soil conditions (0.3m depth) in the PNW compared reasonably well with the corresponding values measured by the in-site incubation technique (Fig. 1). However, measured N mineralization from corn residue was about 56 kg ha⁻¹ higher than predicted N mineralization. For all the residues, measured N mineralization during May-June was higher than model predictions (Fig. 1). Simulated N immobilization, particularly until May-June, could have reduced the estimations of N mineralization. During the simulation period, net N mineralization, was estimated as the difference of N mineralization and immobilization. (Fig. 2). Subsequently, simulated net N mineralization was positive (Fig. 2). Potato growth and N dynamics were simulated for the year 2000 with residue input parameters emulating two different and usual types of residues in the irrigated potato systems. One of them with high load of residue (15 Mg ha⁻¹ of dry matter) and a C/N ratio of 50. This type represents corn or wheat residues. The other type represents potato residues with a load of 5 Mg ha⁻¹ and a C/N ratio of 30. Simulation was done at 336 kg ha⁻¹ N application. Simulated yield was about 82 Mg ha⁻¹ for both situations. Simulations for the potato-type of residue showed that mineralized and available N for crop uptake was about 93 kg ha⁻¹ (net mineralization curve of Fig. 3). For the corn-type of residue situation, simulated mineralized and available N was about 40 kg ha⁻¹ (Fig. 4). Simulations also showed that N from mineralization for the later situation was only available at the end of the growing season. N immobilization may have contributed to the low mineralized available N, particularly during the early growing season.

Conclusions

Model predictions and measured data showed that mineralization of N from different types of residues in irrigated potato cropping systems are dependant on residue loading rate and C/N ratios. Simulations showed that the N mineralized from high amount of incorporated residues with high C/N ratios, like corn or wheat, is expected to be available for crop uptake mostly from the middle to end of the growing season.

References

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